



Open Design and Crowdsourcing: Maturity, Methodology and Business Models

Howard, Thomas J.; Achiche, Sofiane; Özkil, Ali Gürcan; McAloone, Tim C.

Published in:
Design 2012 - International Design Conference

Publication date:
2012

[Link back to DTU Orbit](#)

Citation (APA):
Howard, T. J., Achiche, S., Özkil, A. G., & McAloone, T. C. (2012). Open Design and Crowdsourcing: Maturity, Methodology and Business Models. In *Design 2012 - International Design Conference* (pp. 181-190). Design Society.
http://www.designsociety.org/publication/30980/ds_70_proceedings_of_design_2012_the_12th_international_design_conference_dubrovnik_croatia

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

OPEN DESIGN AND CROWDSOURCING: MATURITY, METHODOLOGY AND BUSINESS MODELS

Thomas J. Howard, Sofiane Achiche, Ali Özkil and Tim C. McAloone

Keywords: Open Design, Open Hardware, Crowdsourcing, Business Models, Open Source, Open Innovation, Open Service, PSS

1. Introduction

Take a look at the modern day products around you that are of any significance in your life; unlike in previous generations, you will probably not understand how these products work and you would be incapable of producing or repairing such products. Though there are many views of product complexity, this is one view suggesting that products are generally getting more and more complex with time. This trend has had dramatic consequences for the nature of innovation, business and entrepreneurship.

This trend towards increased product complexity alongside mass production and economies of scale, have enabled large organisations with great R&D budgets to dominate markets. The contributions of university engineering departments trail large engineering companies rather than lead them. But most importantly, these trends have made it more difficult for entrepreneurs and small/medium sized enterprises (SMEs) to compete, especially in the fields of engineering and technology [Howard et al. 2011]. However, certain technologies have begun to enable individuals to reverse these trends through new paradigms such as Crowdsourcing, Open Innovation, Open Source Design and Open Design (also known as Open Source Hardware).

This article concerns the reaching of age of Crowdsourcing and the emerging paradigm of Open Design. A case study is used to demonstrate how Crowdsourcing can now be used to support virtually every stage of the product development process. The opportunities within Open Design and the beginnings of a new open design methodology, Design for Openness (DfO) are to be explored.

While the open source movement is often considered to be not-for-profit, this paper discusses Open Design business models from a profit making perspective. Having businesses develop their products using an open design strategy will further drive innovation and technology development across the globe in a faster manner, focusing design and development on the drawing board and laboratories rather than the court rooms and patent offices.

2. The paradigms of post industrialisation

Design and product development is currently mid revolution towards an era of post-industrialisation. In this era, information and creativity replaces material as the dominant currency, where stages such as product design, development and production are no longer solely the creation of industry but can now be activated and accomplished by disparate groups of individuals (the crowd). Though it is hard to tell whether this revolution will ever enable individuals to completely overthrow large multinational corporations, the conglomerates should ignore the crowd at their peril!

Behind this revolution enacts 4 paradigms, namely, Open Innovation, Open Source, Crowdsourcing and Open Design (Open Hardware). These paradigms are all related in that they all focus on bringing products to market via alternative routes, taking advantage of larger collaborative networks and the crowd. The paradigms differ in terms of the following three aspects of openness as defined by Balka & Raasch [2010]:

Transparency - refers to the quantity and quality of information which is freely revealed to developers. Information in that sense could, for example, be software source code or hardware schematics and design files.

Accessibility - denotes the possibility for community members to actively participate in product development. This participation may take place in terms of open discussions only or contributions could be directly taken up into official product releases.

Replicability - denotes the availability of individual components and thus the possibility for the hand assembly of the product. Objects including closed components could be copied if those components are obtainable; conversely objects which are entirely open source might not easily be copied if some components are difficult to produce and not obtainable from external suppliers.

These three aspects are encapsulated in Table 1 through issues of Intellectual Property (IP) ownership, the Design & Development work and the manufacture of the product.

Table 1. Open Paradigm Strategies: The roles of the stakeholders

| | Intellectual Property owner | Design & Development work | Manufacturer | Example users |
|------------------------|---|--|---|-------------------------------------|
| Open Innovation | Licensing agreements between stakeholders in a network. | The network. | Either the company or a member of the network | P&G, Eli Lilly, Toyota. |
| Open Source | Few/No ownership rights to the code. | Developed through the crowd. | The user (compiles code) | Linux, Eclipse, OpenOffice, |
| Crowdsourcing | The company (usually). | Product developed by the crowd then taken to market via traditional means. | The company (unless outsourced) | Amazon, BMW, Dell, Adobe, Starbucks |
| Open Design | Few/No ownership rights to the design's blue-prints. | Modified by the crowd | Manufacture as a service (MAAS), the company or the user. | Arduino, RepRap, Willow garage |

NOTE: The above table is viewed from the perspective of 'the company' from which the design and development project originated.

Of the above paradigms (Table 1), Open Innovation will be the most familiar to traditional engineering designers and the manufacturing industry. To caricature this paradigm, open innovation is the collective term meaning business collaboration, IP licensing and the outsourcing/offering of certain design & development activities.

"Open Innovation combines internal and external ideas into architectures and systems whose requirements are defined by a business model. The business model utilizes both external and internal ideas to create value, while defining internal mechanisms to claim some proportion of that value. Open innovation assumes that internal ideas can also be taken to market through external channels, outside the current businesses of the firm, to generate additional value." [Chesbrough, 2003]

Nearly all modern companies practice open innovation to some extent, and as such, open innovation is unlike the other paradigms. It is not something a company does or does not do, but instead comprises of a continuum from the less open (companies which do most development activities themselves for themselves) to the more open (companies whose design & development activities are predominantly co-developed with strategic partners or are conducted on behalf of other companies).

Open source design has far more prominent markers. Open source projects can be identified as a form of software development where the source code is released, allowing contributions from the crowd of developers. The paradigm has proved to be incredibly successful, producing software programs to rivaling those produced by large companies on functionality and often outperforming on cost (they are free)! The success lies with the crowd of developers who contribute their expertise mostly through

good will, to develop products beyond their own capabilities. Not even Karl Marx would have expected the willingness of the volunteers to contribute, support and solve problems, it is staggering! The scope of this paper will now be limited to **Crowdsourcing** (the parallel of Open Innovation except the outsourcing is done to the crowd) and **Open Design** (the hardware version of Open Source).

3. Crowdsourcing: the coming of age

In this section we look at the possibilities now available for developing products through crowdsourcing. In order to do this, we take a product previously developed which takes a traditional route to market called Reelight and investigate the opportunities for development using crowd sourcing. Crowd sourcing is predominantly based around websites where contributors can log in and projects/work packages can be advertised as an open call, or to a targeted group. The crowdsourcing websites chosen for discussion in this section were selected to cover a range of development activities, however, the chosen sites were randomly picked over their direct competitors who are numerous.

3.1. Reelight

The Reelight product is a bike light which uses electrodynamic induction in order to create current to power front and rear bicycle lights. The lights have no requirement for batteries and therefore provide significant benefits and safety to the night time cyclist (see figure 1).



Figure 1. Reelight bicycle lights (Source: <http://reelight.com>)

This product was conceived and patented by an inventor, Troels Pedersen in 1999. Due to lack of available funds, resources and competencies the patent was sold to private investors who further developed the product to bring it to market. If Troels had have conceived his idea ten years later he could have benefitted from support in nearly all aspects of product development through different forms of crowdsourcing.

According to crowdsourcing.org, crowdsourcing comes in the following types: CrowdFunding (22% of sites) CrowdLabour (8% of sites) CrowdInnovation (10% of sites) Distributed Knowledge (37% of sites) CrowdCreativity (*Aesthetics & Branding*) (14% of sites) and Tools (9% of sites). To further the above example, this paper will now focus on CrowdFunding, CrowdInnovation and CrowdCreativity.

3.2. Crowd-Funding

It is now possible to source funding for the development of interesting new projects without giving away vast proportions of your future business to venture capitalists and business angels, and so long as you have a good idea it's simple to do! New crowdfunding websites such as www.kickstarter.com can be used to attract funding (donations) from the crowd. The process involves filling in a very small amount of documentation about the project (see figure 2 – Left) including how much you need to raise and for what, and what rewards will be offered to backers of your project. Typical reward schemes promise 1st edition complete products to the funders, official limited edition merchandise, inside stories about development process, invitations to launch parties but not financial rewards. Promotional material is then created, typically a video (see figure 2 – Right) to convince the crowd to back the project. The project and advert goes live having 30 days to gain 100% of the funding required (all or nothing).

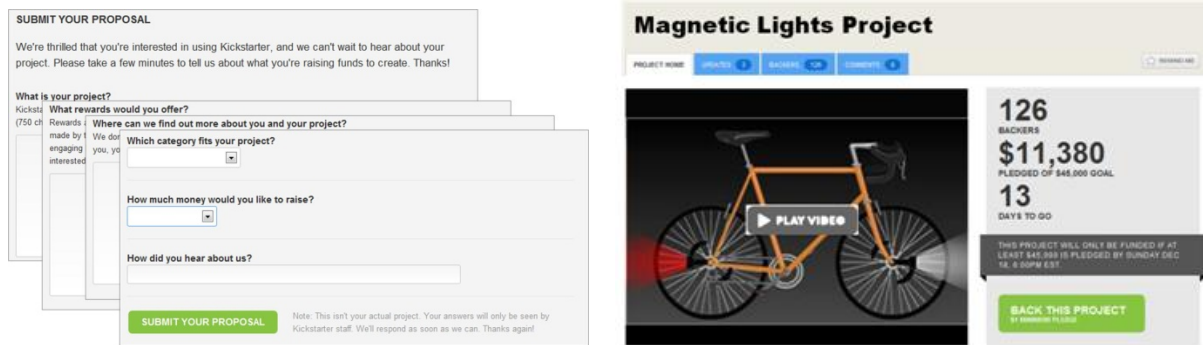


Figure 2. Crowdfunding application form and project advertisement

3.3 Crowd-Innovation

Sites such as www.quirky.com have enabled designers to submit their ideas (see figure 3 – Left) and call upon the crowd to undertake conceptualisation and development work on their behalf (example concepts can be seen in figure 3 – Centre & Right). Quirky encourage contributors by proposing an interesting equity model where developers gain ‘influence’ on the design proportional to their contributions. Percentages of influence are then converted into monetary value as a proportion of product sales.

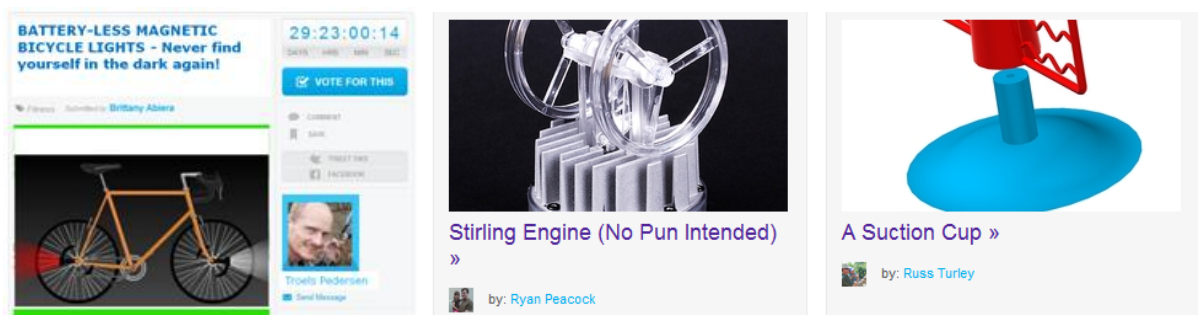


Figure 3. Crowdevelopment advert and 2 example solutions from the crowd

3.4 Crowd-Creativity (*Aesthetics and Branding*)

Many inventors and design engineers do not have expertise in branding and marketing and can therefore draw on the crowd to provide this expertise. For prize money of \$295 inventors can expect around 100 high quality logos to be submitted by the crowd, far quicker and much better values than can be expected from design agencies and output from innovation hubs. The same process can be followed for packaging design and other product styling tasks (see figure 4 for example concepts).



Figure 4. Crowdbanding – Logos, Packaging and Industrial Design

3.5 Conclusion

Crowdsourcing is now a mature field! And it's not just for funding, design and branding; virtually every stage of the product development process can now be achieved through crowdsourcing. In the author's experience of work with design agencies and innovation hubs, the solutions and concepts proposed by the crowd are competitive on quality and ahead on quantity/time, though this should be studied in future research.

We would highly recommend that companies who specialise in product development develop strategies for crowd sourcing. It could be of particular use for plugging temporary lulls in resources and for small companies lacking the resources in general. The crowdsourcing strategies should be developed alongside both the company's design and development process and their approach to portfolio management. To many engineering design firms, crowdsourcing graphic design and market research at the concept level would often make for a sensible strategy. Crowdsourcing possibilities should be built into design process to ensure their consideration and promote awareness amongst the designers.

Portfolio management would also benefit from strategic crowdsourcing. Though more research needs to be done in this area to prove utility, project backlogs could be cleared using crowdsourcing.

While crowdsourcing can now be viewed as a safe, cheap, 'plug-in' to the product development process, Open Design can be viewed as a completely new operating system which requires complete re-conceptualisation of business models, development processes and design processes. The premise of this radically new paradigm is giving the design content away for free in exchange for other forms of value, but is this really a viable premise for product design in companies?

4. Giving things away for free

The culture of intellectual property and consumerism over the past century has ingrained a business attitude that to give the product and its inner workings to the customers and competitors would be commercial suicide. As design engineers we have been educated around the powerful and compelling model of 'business and product development' as maximising the gap between product cost and price. For an example of such a model see figure 5 by Andreasen and Hein [1987] where the designer 'flexes his muscles' to add value to a product by distancing price from cost.

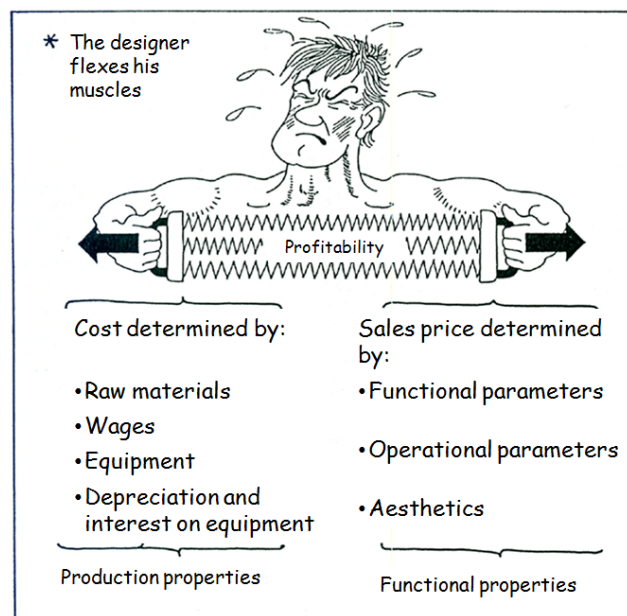


Figure 5. Optimisation of the business: Cost vs. Price [Andreasen & Hein 1987]

Over the recent decade this model has been made redundant through innovative business models as companies attempt to give the products to the customer at low cost and to recuperate value from elsewhere in the value network.

In actual fact companies giving their primary product away for free is now common place, as pointed out by Cuartilles and Bowyer [2011]. Imagine paying every time you wanted to search on the internet. Who pays for an internet browser? Consider all of the internet giants: Google, Facebook, Myspace, Flickr, Twitter etc. they all have something vital in common, that they all provide their product to the end user for free. These products are then able to lever revenue from advertising due to their great influence, popularity and utility. They are also able to charge for extended and professional use of certain programs. Since 'nearly free' is infinitely more expensive than 'free', companies or individuals able to provide for nothing possess the ability to ***destroy their competition and transform industries***, gaining huge market shares in small amounts of time.

For the most pertinent example, consider the revolution of distributing content in the music industry. Formats of hardware were developed that allowed users to copy music so long as they possessed a version from which to copy (usually a friend's). Then came digitalisation of music where CDs were able to be stored digitally making the content more quick and easy to pass between people and devices. Then with the internet came Napster; the peer to peer sharing site enabling the sharing and copying of content on a global scale, bypassing companies. Napster was shortly after closed following legal disputes over copyright; however the seeds had been sown for the sharing of music via the internet.

Feeling safe behind music copyright laws, Apple progressed in its business locking people into iTunes as a requirement for operating Apple hardware devices while continuing to generate revenue through selling digital music through the Apple Store, now the dominant design in music retail. However, in 2010/11 they have been blindsided by spotify.com and its innovative business model which works within the legal framework of music copyright law to provide music to users for free. The model is known as an Advertising – Freemium model where users are exposed to an advert every several songs unless they pay for the premium service which also has many additional benefits.

Spotify has hit critical mass and will continue to grow to facebook proportions and will crush iTunes over the coming years, which will also have to resort to some form of Freemium model to compete or to reposition the purpose of the Apple Store completely.

Spotify also has huge implications for music content providers/creators who will need to be on Spotify to simply be in the game and will thus be squeezed further and further on cost. With a combination of free content to the users, resulting huge growth and influence, Spotify has forced content providers onto a battleground with more competition and less reward.

Whether spotify succeeds to be profitable or not is to a degree inconsequential. Be the first and best at providing content for free or get ready to go out of business. And the winners? The little guys, the users and the small independent content providers who now compete on a more level playing field.

The purpose of this section was to highlight how successful business reconfiguration can be made wherein end users receive the goods/service for free drawing parallels with the Open Design paradigm.

5. The Open Design Paradigm

We can guess by now you are thinking, "giving content away may work in the software and digital domain, but how can this possibly be financially viable for hardware?" Firstly, the Open Design paradigm requires that the design blueprints and knowhow are made freely available and not necessarily the final finished product. Secondly, it is important to note that Open Design encompasses more than giving the design-blueprints to the user for free, but also draws on the expertise and development powers of the users, something spotify has been less able to do. And thirdly, while the physical-manufactured properties of hardware do create some financial barriers, at the same time they actually bring with them some business opportunities.

While it is clear that Open Design is a great strategy for societal innovation, in that it can help bring products to users who otherwise could not afford them, it is less certain how well Open Design operates as a 'for profit' strategy. To better understand this area, this section will focus on the challenges and benefits of Open Design.

5.1. Design-Development benefits of Open Design

There are several key benefits that Open Design can bring as a business & product development strategy. It is vital that product developers understand these benefits in detail so that they are able to use them to their advantage.

5.1.1. Crowd of free developers

One of the biggest benefits of Open Design is its crowd of developers who can also be considered as expert-users. This gives a lot of potential benefits such as increased customer feedback into the development cycle. In addition, the sheer quantity of available developers is a huge benefit, each bringing their own ideas and expertise to the product. As put by Raymond [05] about the same resource in the open source community: “Given enough eyeballs all bugs are shallow”.

5.1.2. Rapid promotion and distribution of the product

The Open Design strategy seems to create a great deal of media coverage, perhaps due to the social networked dimension of Open Design. Contributors are inherently interested in the Open Design movement and the success of individual products and therefore spread the word free of charge through their social networks. People then hear about Open Design products like Arduino, RepRap or even Free Beer 1.0, but haven't the time themselves to make their own, so they buy from the project originator. However, the current successful products of the Open Design paradigm have a certain panache to them which further excites the community, it will be interesting to see how well publicised more mundane Open Design products are.

5.1.3. Product variants

The released digital design can expect to be spun-off into multiple product variants where developers customise the design to their needs and to exercise their creativity. As the users are also part of the development process they are able and willing to accept sub-optimal products. Also, due to the remote and flexible nature of the manufacturing, mistake can be easily corrected by updating the digital blueprints of the product.

5.2. Design-Development challenges facing Open Design

There are at present three main problems facing the Open Design community where it is not directly analogous to Open Source software development, namely, manufacture, design complexity and design validation. However, all three problems have foreseeable, feasible solutions.

5.2.1. The problem of manufacture

Looking back to Table 1, the big difference between the uptake of Open Source and Open Design is likely to be based on the issue of manufacturing. While users are able to compile Open Source code at no cost in order to experience the final product, in comparison, Open Design blueprints still need to be transformed to a physical medium at a cost to the end user in the form of materials and manufacturing processes/capabilities. This has prompted previous authors to claim that “Software is more open than hardware” [Balka & Raasch 2010].

Projects such as Arduino and RepRap have made this process much more simple for the consumer who can now benefit from home manufacturing and simple to program electronics. These two products and their variants will be instrumental in making viable business models for Open Design projects. In addition to the home manufacturing and prototyping technologies, MAAS (Manufacturing As A Service) companies are gaining in popularity, specialising in rapid, flexible manufacturing. It is predicted by the author that growth and popularity in Open Design will be mirrored by that of MAAS. However, the cost of materials and manufacture need not be seen as a downside. Arduino still have orders of over 20,000 units/year despite their boards being completely open to copy. This is because consumer may not have the time to build their own but have heard of the project through the publicity generated from throughout the community and would like to purchase a readymade board from the originators. The project originators also have an inherent quality guarantee.

5.2.2. The problem of complexity

“The key to a successful open design framework is having a robust web portal where engineers ‘meet’ to collaborate on projects” [Koch & Turner 2009]. There is a great deal of truth to this statement as Open Design is waiting for its very own Source Forge (the dominant collaboration platform for open source designers). Brilliantly put by Koch and Turner [09], “why are robust collaboration tools openly available to the programmer, but not the designer?”

In the Open Design community we can observe the sharing and modification of complete designs. Designers download a complete design, modify it, and then upload their new complete design as product variant onto platforms sites such as thingiverse.com. ***The open design community do not currently share and work on partial designs!*** It is therefore no surprise that the products of open designs are generally simple products achievable by individuals. If the community hope to achieve impact comparable to that of the open source movement ***we must begin to organise to collaborate on partial designs***, so that complexity can be built into the products produced.

5.2.3. The problem of validating designs

A major limitation to Open Design is in the validation, testing and reliability of designs. Consider an Open Design turbojet engine or car. It is feasible that an online community could synthesise and optimise towards promising digital designs, but where would the testing of the entire system be conducted? Specialist facilities would need to be available for high precision manufacturing and testing, particularly for complex and safety critical designs.

5.3. Open Design business models

Until now, creators of Open Designs have managed to lever value from their projects by the following strategies:

1. Guest lectures and corporate speeches based on the product
2. Consultancy on how to use, modify, and configure the product
3. Advertising on their product and website
4. Direct sales of the product and its variants
5. Spin-off products and services

If open design is to work commercially, business models need to be more creative drawing value from the actor network and the user and developer activity cycles throughout the product life cycle (see the next section). In addition to the above, the authors would like to propose the ‘Component Promotion Model’ where support is provided by component suppliers to include their components in the default design with advertising links to the suppliers from the bill of materials on the website.

6. Design for Openness (DfO): An Open Design Methodology

For Open Design to have any chance of success in a commercial setting, the methodology must be created in the wake of integrated product development, where the business model is design in parallel to the product and the production system.

6.1. Staging the Open Design Project

The starting point for new design projects should be to form the following mindset:

“To design a product and business model that makes a virtue of and levers value from publicising the blueprints of a design, encouraging its distribution, copying and modification.”

It is then important to ask the fundamental question as to whether the project makes sense to progress as an Open Design project:

“Why would an open version of this product be of benefit and to whom?”

Some products make much more sense as Open Designs than others. This has to do with how the end user interacts with the product. Products bought and owned by end users probably have a better chance of success as an Open Design which is further increased if the product is used frequently used or if it enhances the user’s capabilities in some way. An Open Design Automobile will be a greater success than an Open Design Jet Engine.

6.2. The Life and Activities of an Open Design

To aid in the creation of an Open Design methodology, some of the models from the Product/Service-System (PSS) paradigm have been adopted and modified. By considering the design as a PSS, possibilities for different configurations of openness are made evident. For example, you could produce: an Open Design but closed service, a closed design but Open Service or a complete Open Product/Service-System. It may be possible to generate revenue from any of these components.

Based on previous literature [Tan et. al, 2006] it is important to consider both the product life cycle and the customer activity cycle when conceptualising a PSS. In order to bring this in line with the Open Design paradigm, the developers' activity cycle can also be added to the model (see figure 6). It is important to note that the customer/user and the developer may be the same person in many instances which can provide very close feedback loops from the use cycle back to the development cycle. From figure 6 we can see that there are two products to consider in Open Design. Firstly, the virtual product (blue) produced at the end of the design phase, which is to be made 'Open' and available. The second product is the tangible, finished artefact which is then used by the end user. Although only two activity cycles are shown in figure 6, there will also be a user/developer activity cycle for the entire production-assembly phase (omitted from figure 6 for clarity).

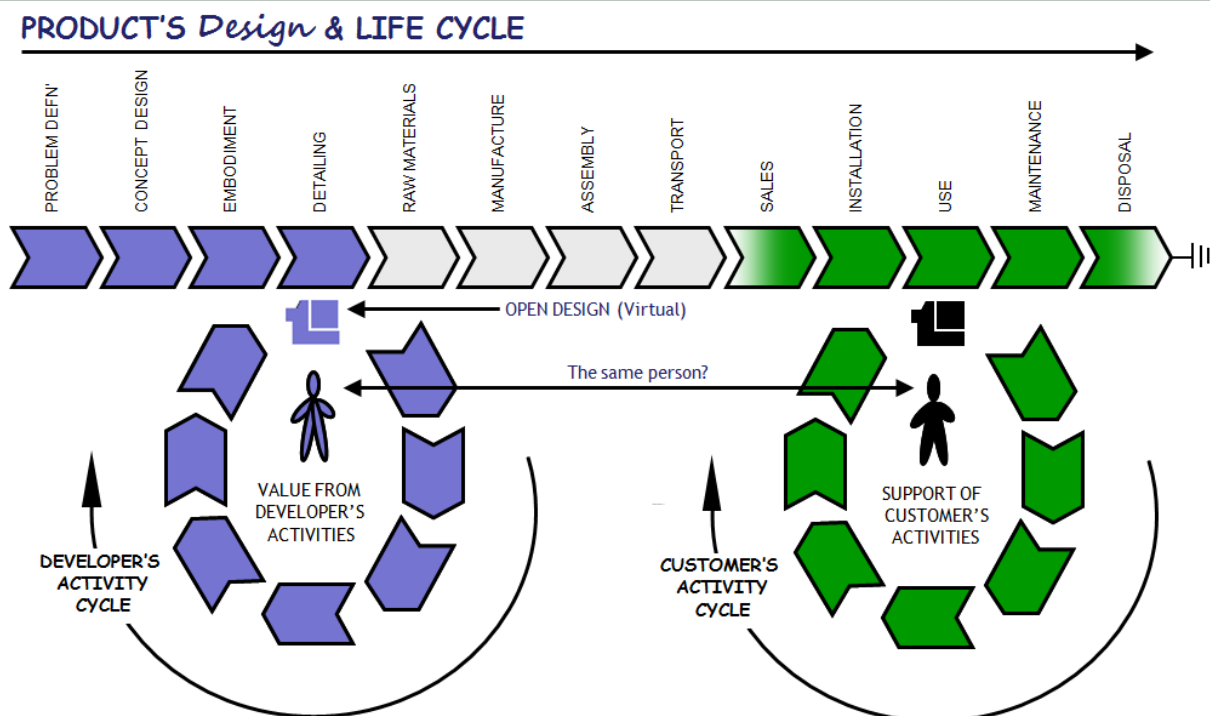


Figure 6. An Open Design's Life and Activities

For each new project, the Open Design Life and Activities should be conceptualised. This means for each activity and each product life phase ask:

1. Can extra value be added to the product during this phase or activity? And,
2. Can revenue be gained from this phase or activity?

Both of the above questions are incredibly important for Open Design; however, the latter is more difficult.

6.2. Licenses

Unfortunately, Open Design is not an IP free paradigm (though it's a lot more free!). There are several very important Creative Commons (CC) licences which need to be understood and built into the business model from an early stage. All CC licences require attribution to the originator (or original design). There are then several options as seen from figure 7. The most suitable is the ShareAlike version which ensures branches of the design's development is not halted due to IP rights.

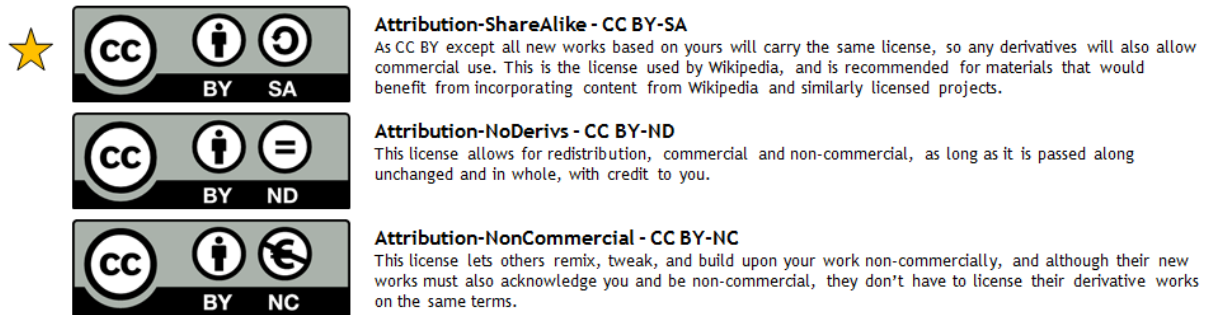


Figure 7. The Creative Commons Licences

7. Conclusions

The crowd are gaining in strength and numbers and what's more they're now organised. Crowd sourcing is now mature field and a resource the companies really should begin to consider to use more strategically. For many tasks, the crowd will outperform design agencies in quantity, quality, time and cost. Companies should consider building crowd resources into their stage-gate models and linking to their portfolio management strategies.

At the start of this paper it was suggested that a revolution was currently in act, moving from closed intellectual property business models to Open Design business models. But when will the revolution be complete? Well, you cannot expect industry to be completely replaced by the crowd, but we can perhaps expect to see the following two transitions take place:

- Industry begins to follow and organise around the crowd of developers
- Devaluation of patents and a swing of popularity for creative commons licences

Developing a for-profit Open Design Methodology will benefit society hugely as it will promote innovation and concentrate spending on R&D rather than litigation. This paper lays out the beginnings of a Design for Openness (DfO) methodology, drawing inspiration from the PSS movement. It is proposed that the Developer, Producer and User Activity cycles be drawn against the product life cycle to pinpoint value creation and revenue creation.

Acknowledgements

Thank you to Troels Pedersen who provided the case and for his constructive comments regarding the research. Also, many thanks to the entire Open Source and Open Design community of volunteers who have made this interesting research area viable and continue to enrich our society with their efforts.

References

- Andreasen, M., Hein, L., "Integrated Product Development", 1987
- Balka, K., Raasch, C., "How Open is Open Source? – Software and Beyond", *Creativity and Innovation Management*, Vol.19, No.3., 2010, pp 248-256.
- Balka, K., Raasch, C., Herstatt, C., "Open source enters the world of atoms: A statistical analysis of open design", *First Monday*, Vol.14, No.11., 2009, pp 248-256.
- Bowyer, A., Cuartilles, D., "Creating wealth by giving it away", *ICED11 Conference 2011, Copenhagen* <http://podcast.llab.dtu.dk/fileadmin/podcasts/ICED11/ICED11-20110917-3.3.K7-Mechatronics-360p.mp4>
- Chesbrough, H., *Open Innovation: The new Imperative for Creating and Profiting from Technology*. Boston, Massachusetts: Harvard Business School Press. 2003
- Howard, T.J., McMahon, C.A. & Giess, M.D., "How design researchers can lead higher education to a greater impact on society" *proceeding of the ICED11 Conference 2011, Copenhagen*, Vol. 3, pp.1-10
- Koch, M. D., Tumer, I. Y., "Towards Open Design: The Emergent Face of Engineering - A Position Paper", *Proceedings of ICED'09*, Vol.3, No.11., 2009, pp 97-108.
- Raymond, E., "The Cathedral and the Bazaar", *First Monday*, Special Issue #2: Open Source, 3 October 2005
- Tan, A., McAloone, T.C., Andreasen, M., "What happens to integrated product development Models with product/service-system approaches?", *The 6th Integrated Product Development workshop*, 2006

Thomas J. Howard, Associate Professor, Dept. Mechanical Engineering, DTU - thow@mek.dtu.dk, <https://sites.google.com/site/thomasjameshowardhomepage/home>